PHE 219.2
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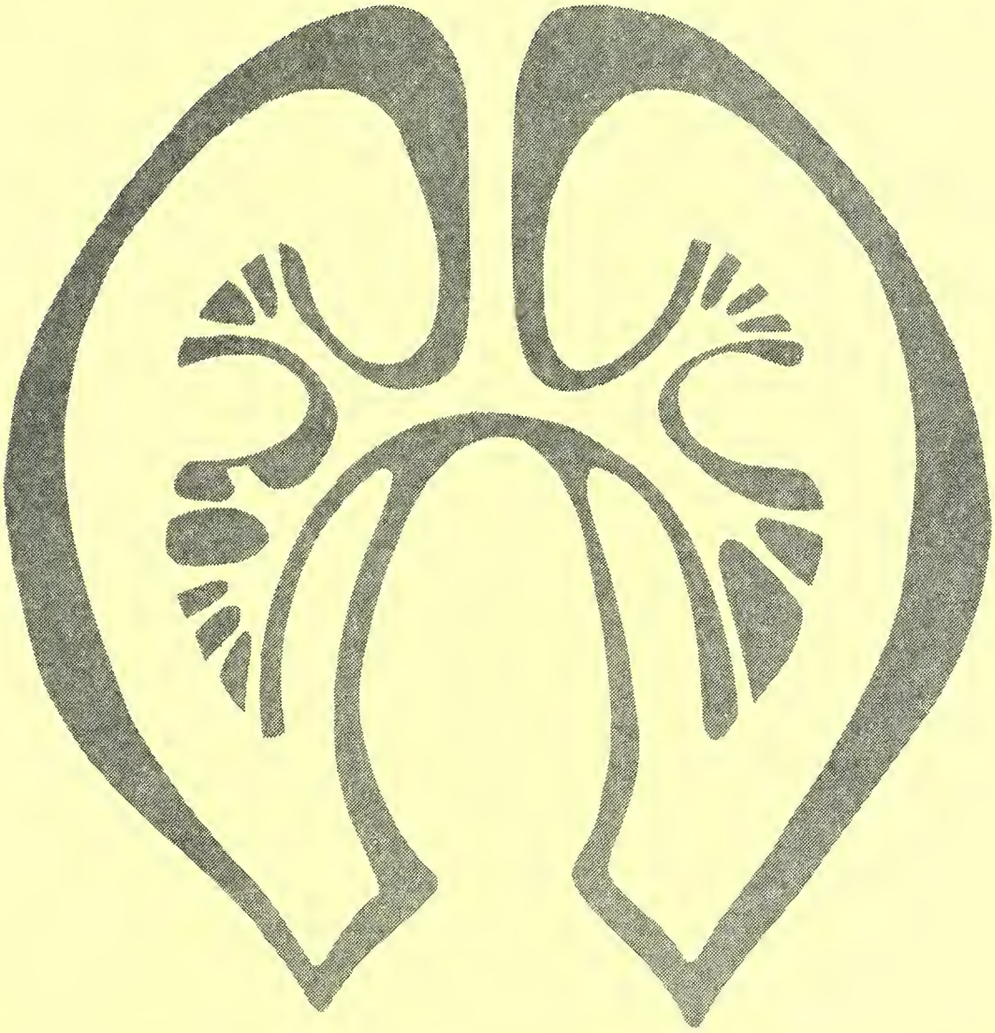
THE TRANSMISSION AND PATHOGENESIS OF TUBERCULOSIS



A 2 DAY SYMPOSIUM FOR PHYSICIANS
MARCH 13 & 14, 1974
HERSHEY MEDICAL CENTER

DIVISION OF CHRONIC RESPIRATORY DISEASES
PENNSYLVANIA DEPARTMENT OF HEALTH

THE TRANSMISSION AND PATHOGENESIS OF TUBERCULOSIS

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Public Health Service
Center for Disease Control
State and Community Service Division
Tuberculosis Branch
Atlanta, Georgia 30333

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P R E F A C E

Correct diagnosis and proper management of the patient with tuberculosis demand that the physician be informed about this disease.

Further, the basis of this understanding should rest on an appreciation of the transmission and pathogenesis of the tubercle bacillus. Knowledge in these two areas is necessary if rational care is to be given to the patient infected with or diseased by *Mycobacterium tuberculosis*. The reason, therefore, for this programmed instruction text is to provide the physician with this information base. The program is intended for readers who have a basic understanding of human anatomy and pathology. Hopefully, the physician in training and practice will find this instruction useful in his work.

The teaching of tuberculosis receives little or no emphasis in many areas of the United States today. In part, this is because many people feel that this disease is no longer a significant health problem in our country.

However, 43,000 new active cases of tuberculosis were discovered in 1968. This occurred in a nation which has an estimated 23,000,000 people who have already been infected with the tubercle bacillus.

These two dimensions alone underline the importance of this disease at the present time. There is, though, an even more basic responsibility as far as the physician and tuberculosis are concerned: this is the obligation on the part of the physician to recognize a disease state which is curable. Proper therapy in this instance must rest on proper diagnosis; and proper diagnosis relies on a continual awareness that tuberculosis is still very much with us.

Finally, even a text as brief as this reflects the contributions and efforts of many people.

Among them have been Seth Leibler, Ed.D., who introduced the writer initially to the basic tenets of learning upon which this program is based, and who has nursed the project along. As well, Mrs. Marybet Payne has provided continual secretarial assistance in addition to valuable program evaluation aid. Drs. Alfonso H. Holguin, Phyllis Q. Edwards, Vernon N. Houk, Laurence S. Farer have reviewed the various manuscripts of this program and contributed sound advice and counsel. Mr. John Olson and Miss Anna Frick of the Instructive Communications Unit reviewed earlier versions of this program, and made important suggestions subsequently incorporated into later drafts.

Drs. Constantine Korski and Ingrid Stergus of the staff of Battey State Hospital, Rome, Georgia, have not only provided helpful commentary, but made available for reproduction many of the pathological and radiological illustrations used in this text.

Conceptually, there is a very real obligation to Dr. William Stead for his contributions concerning the pathogenesis of tuberculosis, and to Dr. Richard Riley for his work concerning the transmission of the tubercle bacillus.

Thanks are also due to Mr. Wendy Watterson and Miss Carolyn Nelson for the art work and aid in the preparation of this program for publication.

Lastly, I am grateful to my colleagues--especially those in the Training Unit of the Tuberculosis Branch--who have taken time to review earlier drafts of this program, and whose comments have proven stimulating in the best professional sense. The virtue, if any, of this program is a reflection of the efforts of these people and all the others who generously gave help as needed. The defects in the program reflect the author's point of view, and as these faults are identified, will be changed in future versions of this work.

C.J.H. 7/11/69

INSTRUCTIONAL OBJECTIVES FOR PHYSICIANS

TRANSMISSION

1. Given a series of questions about the droplet nucleus theory of the transmission of tuberculosis, the physician will be able to select the correct answer from several alternatives.
2. The physician will be able to list four factors which decrease the number of infectious droplet nuclei in the air.
3. The physician will be able to list two factors which contribute to the chance of infection with the tubercle bacillus.
4. The physician will be given several pairs of statements dealing with the implications of current knowledge of the transmission of tuberculosis. He will be able to rank each member of the pair in order of effectiveness in preventing the transmission of tuberculosis.

PATHOGENESIS

1. Given a series of phrases describing the pathogenesis of primary and post-primary tuberculosis, the physician will be able to correctly match each phrase with one or more, usually associated, terms.
2. The physician will be able to list the common local and systemic complications that may be seen in patients with primary tuberculosis.

Programmed instruction is an individualized technique which allows material to be presented in small, logical sequences. The learner is able to proceed at his own pace, and to determine his own progress. It is not necessary to complete the entire program at one sitting, but rather as free time allows.

With this in mind, let's begin:

SECTION 1

TRANSMISSION OF TUBERCULOSIS

1

MAN IS THE CHIEF RESERVOIR IN NATURE FOR MYCOBACTERIUM TUBERCULOSIS (THE TUBERCLE BACILLUS).

AND, IN MAN, TUBERCULOSIS IS ALMOST EXCLUSIVELY AN AIRBORNE ACQUIRED INFECTION.

NO RESPONSE

2

THE TUBERCLE BACILLUS IS SPREAD FROM ONE PERSON TO ANOTHER USUALLY BY AN _____ ROUTE.

AIRBORNE

3

THE NEED FOR A LIVING HOST REPRESENTS A SERIOUS EVOLUTIONARY MISTAKE ON THE PART OF THE TUBERCLE BACILLUS.

IF THIS ORGANISM IS HALTED IN ONE HOST, WE CAN THEN PREVENT TRANSMISSION TO

_____.

ANOTHER HOST (OR EQUIVALENT TERMS)

4

UNFORTUNATELY FOR MAN, HE IS AN EFFECTIVE TRANSMITTER OF THE TUBERCLE BACILLUS.

THIS TRANSMISSION, AS WE HAVE SEEN, IS CHIEFLY VIA AN _____ROUTE.

AIRBORNE

5

COUGHING, SNEEZING AND SIMILAR RESPIRATORY MOVEMENTS BY A PATIENT WITH ACTIVE PULMONARY TUBERCULOSIS, FILLS THE AIR ABOUT HIM WITH DROPLETS OF MOISTURE.

THE LARGER DROPLETS OF THIS AEROSOL FALL TO THE GROUND LEAVING SMALLER DROPLETS SUSPENDED IN THE _____. AIR

6

THE SMALLER DROPLETS IN TURN EVAPORATE LEAVING BEHIND VERY SMALL DRIED RESIDUES, OR 'DROPLET NUCLEI' SUSPENDED IN THE _____. AIR

7

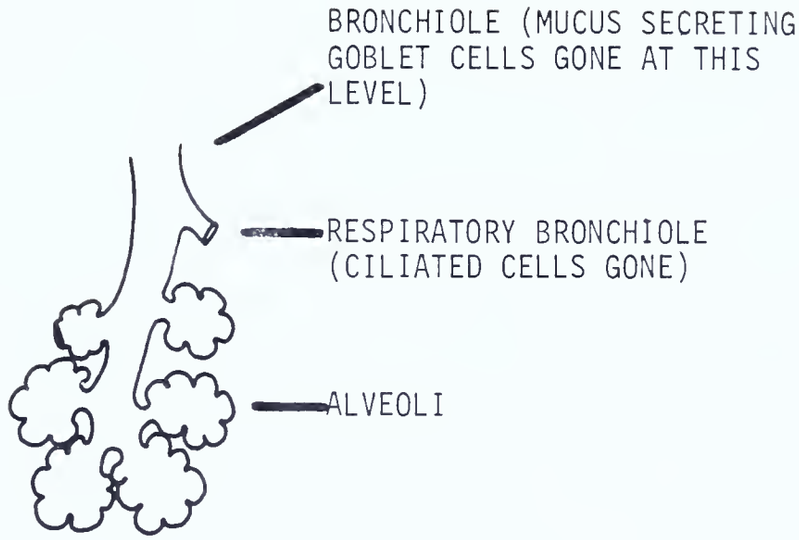
DROPLET NUCLEI, 1-5 MICRONS IN DIAMETER, PRODUCED BY THE PATIENT WITH ACTIVE PULMONARY TUBERCULOSIS, MAY CONTAIN ONE OR MORE _____.

TUBERCLE BACILLI

8

THE VEHICLES RESPONSIBLE FOR THE AIRBORNE TRANSMISSION OF TUBERCULOSIS, WHICH MAY CONTAIN ONE OR MORE TUBERCLE BACILLI, AND WHICH ARE OF THE ORDER 1-5 MICRONS, ARE CALLED _____.

DROPLET NUCLEI



9

DROPLET NUCLEI, 1-5 MICRONS, CAN BE CARRIED BY THE INSPIRED AIR BEYOND THE MUCUS SECRETING GOBLET CELLS AND CILIATED CELLS OF THE LUNG. TUBERCLE BACILLI, SO TRANSPORTED, CAN BE CARRIED DIRECTLY TO THE _____.

ALVEOLI

10

LET'S NOW LOOK AT FOUR WAYS WHICH CAN BE USED TO BLOCK INFECTIOUS DROPLET NUCLEI FROM GETTING TO THE ALVEOLI OF A PATIENT IN THE FIRST PLACE.

NO RESPONSE

11

BECAUSE OF THEIR SIZE, DROPLET NUCLEI CAN BE RAPIDLY DISPERSED THROUGHOUT THE VENTILATION SYSTEM OF A HOSPITAL. IMPROPER VENTILATION CAN THEREFORE SPREAD INFECTIOUS _____, 1-5 MICRONS, TO WARDS FAR REMOVED FROM THE INITIAL SITE.

DROPLET NUCLEI

12

THUS, THERE IS A NEED FOR PROPER VENTILATION TO THE OUTSIDE FOR ALL AIRBORNE DISEASES. AIR FROM THE ROOM OF A PATIENT WITH ACTIVE PULMONARY TUBERCULOSIS SHOULD BE VENTED TO THE _____.

OUTSIDE

13

ADEQUATE CHEMOTHERAPY - THAT IS, THE PROPER DRUGS TAKEN BY THE PATIENT FOR A SUFFICIENT LENGTH OF TIME - IS A SECOND WAY WHICH CAN REDUCE THE NUMBER OF CONTAMINATED DROPLET NUCLEI EXISTING IN THE AIR.

NO RESPONSE

14

TWO FACTORS THEREFORE WHICH WILL REDUCE THE NUMBER OF INFECTIOUS DROPLET NUCLEI IN THE AIR ARE:

1. _____ VENTILATION TO THE OUTSIDE

2. _____ CHEMOTHERAPY

15

WHICH ONE OF THE TWO MEASURES MENTIONED WILL SUPRESS THE COUGH AND HALT THE EXCRETION OF DROPLET NUCLEI WITHIN WEEKS? CHEMOTHERAPY

_____

16

THE TRADITIONAL INSISTENCE ON GOWNING AND MASKING WARD PERSONNEL BEARS REVIEW.

FIRST, ANOTHER QUESTION FOR YOU TO ANSWER - WHO, AFTER ALL, IS PRODUCING INFECTIOUS DROPLET NUCLEI IN THE FIRST PLACE?

_____.

THE PATIENT

17

EDUCATING THE PATIENT TO COVER A COUGH, SNEEZE AND SIMILAR RESPIRATORY MOVEMENTS MATERIALLY REDUCES THE AMOUNT OF AEROSOL HE PRODUCES.

THE LESS AEROSOL GENERATED, THE FEWER INFECTIOUS _____THAT ARE PRODUCED.

DROPLET NUCLEI

18

ASKING THE PATIENT TO COVER HIS MOUTH WHEN HE COUGHS IS A SIMPLE, EFFECTIVE AND CHEAP WAY TO HINDER THE _____TRANSMISSION OF TUBERCULOSIS.

AIRBORNE OR DROPLET NUCLEI

19

IF THE PATIENT REFUSES OR CANNOT COVER HIS MOUTH, THEN HE IS THE ONE WHO SHOULD BE _____.

MASKED

20

AT BEST, MASKING WARD PERSONNEL OFFERS ONLY PARTIAL PROTECTION. THE PORE SIZE OF MANY MASKS WILL NOT SCREEN OUT DROPLET NUCLEI OF THE ORDER WE HAVE BEEN CONSIDERING, WHICH IS ____TO____MICRONS.

1-5

21.

FREQUENTLY, PAPER MASKS BECOME WET AND RAPIDLY LOSE THEIR ABILITY TO SCREEN OUT DROPLET NUCLEI 1-5 MICRONS. BESIDES, THERE ARE MORE IMPORTANT MEASURES WHICH WILL REDUCE THE NUMBER OF INFECTIOUS DROPLET NUCLEI IN THE AIR. THEY ARE:

1._____

2._____

3._____

PROPER VENTILATION TO THE OUTSIDE

ADEQUATE CHEMOTHERAPY

EDUCATION OF THE PATIENT (MASKING IF NEEDED)

22

ULTRAVIOLET LIGHT IS LETHAL TO TUBERCLE BACILLI.

THEREFORE, ULTRAVIOLET LIGHT, PROPERLY USED, CAN AID IN REDUCING THE NUMBER OF INFECTIOUS _____ IN THE AIR.

DROPLET NUCLEI

23

THE USE OF ULTRAVIOLET LIGHT SHOULD ONLY BE CONSIDERED AS AN AUXILIARY MEASURE.

NO RESPONSE

CHEMOTHERAPY----------	REDUCE THE NUMBER OF INFECTIOUS DROPLET NUCLEI ADDED TO THE AIR	
EDUCATION OF THE PATIENT (MASKING IF NEEDED)----------		
PROPER VENTILATION TO THE OUTSIDE----------	AID IN THE REMOVAL OF INFECTIOUS DROPLET NUCLEI FROM THE AIR	
ULTRAVIOLET LIGHT----------		
		NO RESPONSE

25

DISHES, SHEETS AND OTHER OBJECTS USED BY THE PATIENT SHOULD BE OF LITTLE CONCERN AS SOURCES OF INFECTION. IF CONTAMINATED PARTICLES ARE SHED INTO THE AIR, THEY ARE ORDINARILY TOO LARGE TO LEAD TO THE _____ TRANSMISSION OF TUBERCULOSIS.

AIRBORNE

26

ANY ORGANISMS ACQUIRED FROM THESE MATERIALS CAN BE EFFECTIVELY AND SIMPLY REMOVED BY HANDWASHING.

NO RESPONSE

27

THE MODE OF SPREAD OF THE ATYPICAL MYCOBACTERIA IS UNKNOWN.

IN CONTRAST, TUBERCULOSIS IS GENERALLY SPREAD BY AN _____ROUTE, USING INFECTIOUS _____ AS THE VEHICLE.

AIRBORNE

DROPLET NUCLEI

28

TO DATE, THERE HAVE BEEN NO REPORTED INSTANCES OF _____TRANSMISSION OF ANY OF THE ATYPICAL MYCOBACTERIA.

AIRBORNE

29

SO FAR, WE HAVE REVIEWED MEASURES WHICH AFFECT THE NUMBER OF INFECTIOUS DROPLET NUCLEI IN THE AIR.

FOR INFECTION TO OCCUR, THE DURATION OF EXPOSURE IS IMPORTANT AS WELL AS THE _____ OF INFECTIOUS DROPLET NUCLEI IN THE AIR.

NUMBER, AMOUNT (OR EQUIVALENT TERM)

30

BRIEF EXPOSURE TO A HEAVILY CONTAMINATED ENVIRONMENT MAY RESULT IN INFECTION WITH THE TUBERCLE BACILLUS.

GENERALLY SPEAKING, IT TAKES PROLONGED PERIODS OF EXPOSURE BEFORE _____ OCCURS.

INFECTION

31

TWO FACTORS THAT CONTRIBUTE TO THE CHANCE OF INFECTION WITH THE TUBERCLE BACILLUS ARE:

1. THE NUMBER OF DROPLET NUCLEI IN THE AIR.
2. _____

THE DURATION OF EXPOSURE (OR EQUIVALENT TERMS)

32.

THE PATIENT WITH KNOWN TUBERCULOSIS, PROPERLY DIAGNOSED AND HANDLED, REPRESENTS LITTLE INFECTIOUS HAZARD. AS A PUBLIC HEALTH AND WARD PROBLEM, THE REAL DANGER COMES FROM PATIENTS WITH _____ DISEASE.

UNSUSPECTED, UNDIAGNOSED (OR EQUIVALENT TERM)

33

LIST FOUR FACTORS WHICH DECREASE THE NUMBER OF INFECTIOUS DROPLET NUCLEI IN THE AIR:

1. _____

2. _____

3. _____

4. _____

IN ANY ORDER:

- CHEMOTHERAPY
- PATIENT EDUCATION (MASKING IF NEEDED)
- PROPER VENTILATION TO THE OUTSIDE
- ULTRAVIOLET LIGHT

34

LIST TWO FACTORS WHICH CONTRIBUTE TO THE CHANCE OF INFECTION WITH THE TUBERCLE BACILLUS:

1. _____

2. _____

IN EITHER ORDER:

- THE NUMBER OF DROPLET NUCLEI IN THE AIR
- THE DURATION OF EXPOSURE

35

A HEALTHY INDEX OF SUSPICION FOR TUBERCULOSIS MAY KEEP YOU AND OTHERS FROM BECOMING INFECTED.

NO RESPONSE

SECTION 2

PATHOGENESIS OF TUBERCULOSIS

THE DEVELOPMENT OF EXUDATIVE AND GRANULOMATOUS LESIONS.....FRAMES 1 - 17

THE BACTEREMIA OF PRIMARY TUBERCULOSIS, AND SYSTEMIC SITES OF IMPLANTATION.....FRAMES 18 - 37

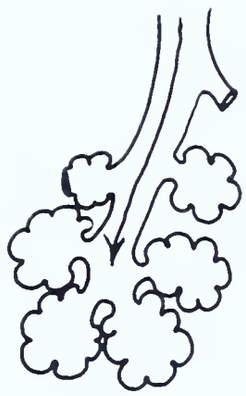
THE REACTIONS OF THE HOST.....FRAMES 38 - 42

THE USUAL COURSE OF EVENTS IN PRIMARY TUBERCULOSIS.....FRAMES 43 - 54

THE LOCAL COMPLICATIONS OF PRIMARY TUBERCULOSIS.....FRAMES 55 - 78

THE SYSTEMIC COMPLICATIONS OF PRIMARY TUBERCULOSIS.....FRAMES 79 - 88

SUMMARIZING THOUGHTS ABOUT THE PATHOGENESIS OF TUBERCULOSIS.....FRAMES 89 - 97



1

TUBERCLE BACILLI CAN BE CARRIED BY DROPLET NUCLEI PAST THE MUCO-CILIARY DEFENSES OF THE LUNG DIRECTLY TO THE _____.

ALVEOLI

2

CIRCLE ONE OF THE FOLLOWING UNDERLINED TERMS:

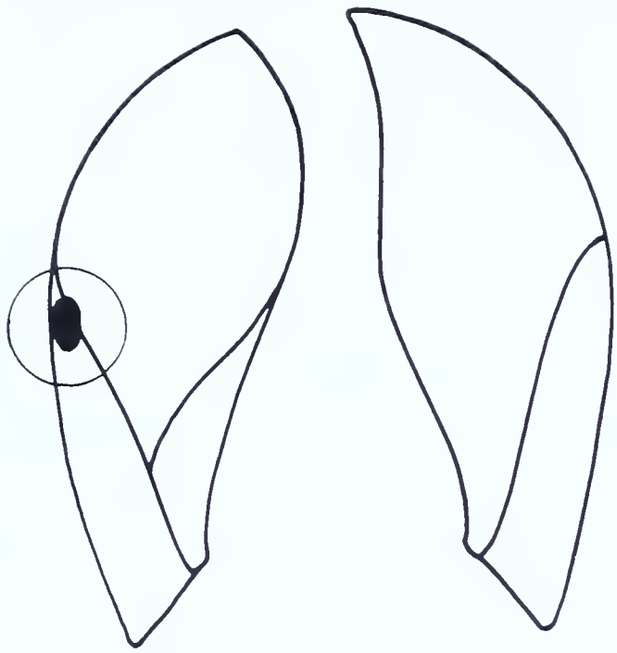
IN THE UPRIGHT POSITION, THE VENTILATION AND PERFUSION OF THE LUNG INCREASE AS ONE GOES FROM THE APEX TO THE BASE.

THIS FACT MAY HELP TO EXPLAIN WHY TUBERCLE BACILLI--VIA DROPLET NUCLEI--ARE INITIALLY DEPOSITED IN THE

UPPER, LOWER,

LOBES OF THE LUNG.

LOWER



3

THE INITIAL SITE OF IMPLANTATION
OF THE TUBERCLE BACILLUS IS
USUALLY IN A PERIPHERAL
ALVEOLUS (ALVEOLI) IN THE
LOWER LOBES OF THE LUNG
JUST BENEATH THE _____.

PLEURA

4

ONCE SETTLED IN ITS PERIPHERAL SUB-PLEURAL LOCATION, THE TUBERCLE BACILLUS ELICITS AT FIRST A NON-SPECIFIC RESPONSE.

MUCH AS IN A BACTERIAL PNEUMONIA, THIS INITIAL EXUDATIVE LESION IS COMPOSED OF POLYMORPHONUCLEAR LEUKOCYTES, EDEMA FLUID AND FIBRIN.

NO RESPONSE

5

THE EXUDATIVE LESION IS REALLY A SMALL AREA OF TUBERCULOUS _____.

PNEUMONIA

6

THUS, THE INITIAL SMALL AREA
OF TUBERCULOUS PNEUMONIA,
WHICH IS THE _____LESION,
IS LOCATED IN PERIPHERAL_____,
BENEATH THE _____, IN THE
LOWER _____OF THE LUNG.

EXUDATIVE
ALVEOLI
PLEURA
LOBES

7

THE FIRST TYPE OF PATHOLOGIC
CHANGE PRODUCED IN THE LUNG BY
THE TUBERCLE BACILLUS AND
REPRESENTED BY A NON-SPECIFIC
EXUDATE IS CALLED THE
_____LESION

EXUDATIVE

8

THE EXUDATIVE LESION HAS

TWO BASIC OPTIONS OPEN TO IT:

1. IT MAY HEAL, OR

2. IT MAY _____.

WORSEN OR PROGRESS

9

INITIAL EXUDATIVE LESION

HEALING

PROGRESSION

PROGRESSION MAY LEAD TO

MASSIVE TISSUE NECROSIS,

OR MORE COMMONLY, TO THE

ESTABLISHMENT OF THE

HISTOLOGIC HALLMARK OF

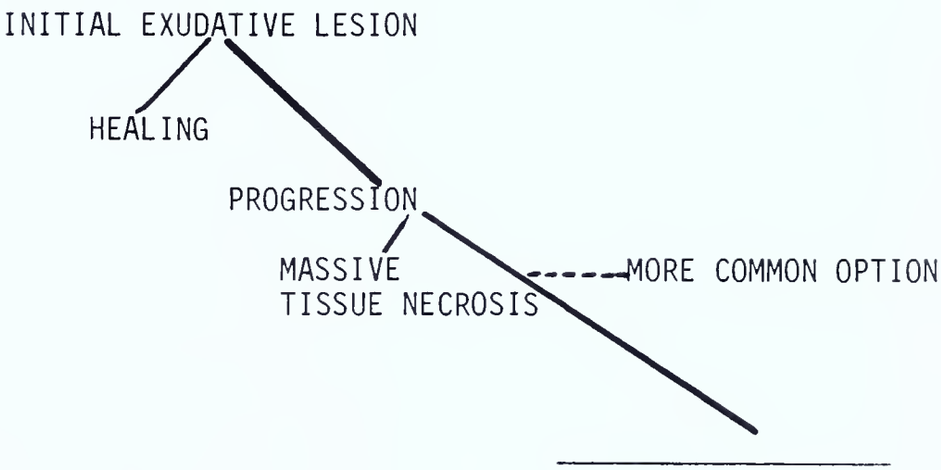
TUBERCULOSIS, THE GRANULOMA

OR TUBERCLE.

NO RESPONSE

10

COMPLETE THE FOLLOWING DIAGRAM:



GRANULOMA OR

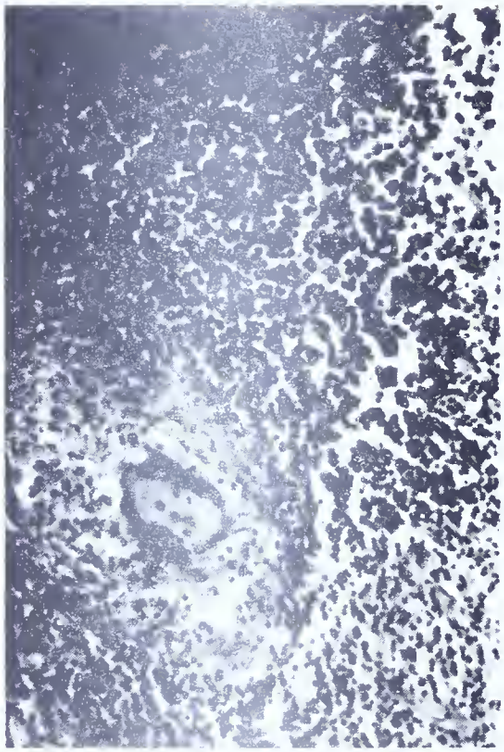
TUBERCLE FORMATION

11

THE GRANULOMA OR TUBERCLE:

PERIPHERAL
MONONUCLEAR CELLS

EPITHELIOID
CELLS AROUND
A LANGHANS GIANT
CELL



12

IN TURN, THE GRANULOMA OR TUBERCLE

HAS THE SAME TWO BASIC OPTIONS

OPEN TO IT AS DID THE EXUDATIVE LESION:

1. IT MAY _____OR,
2. IT MAY _____.

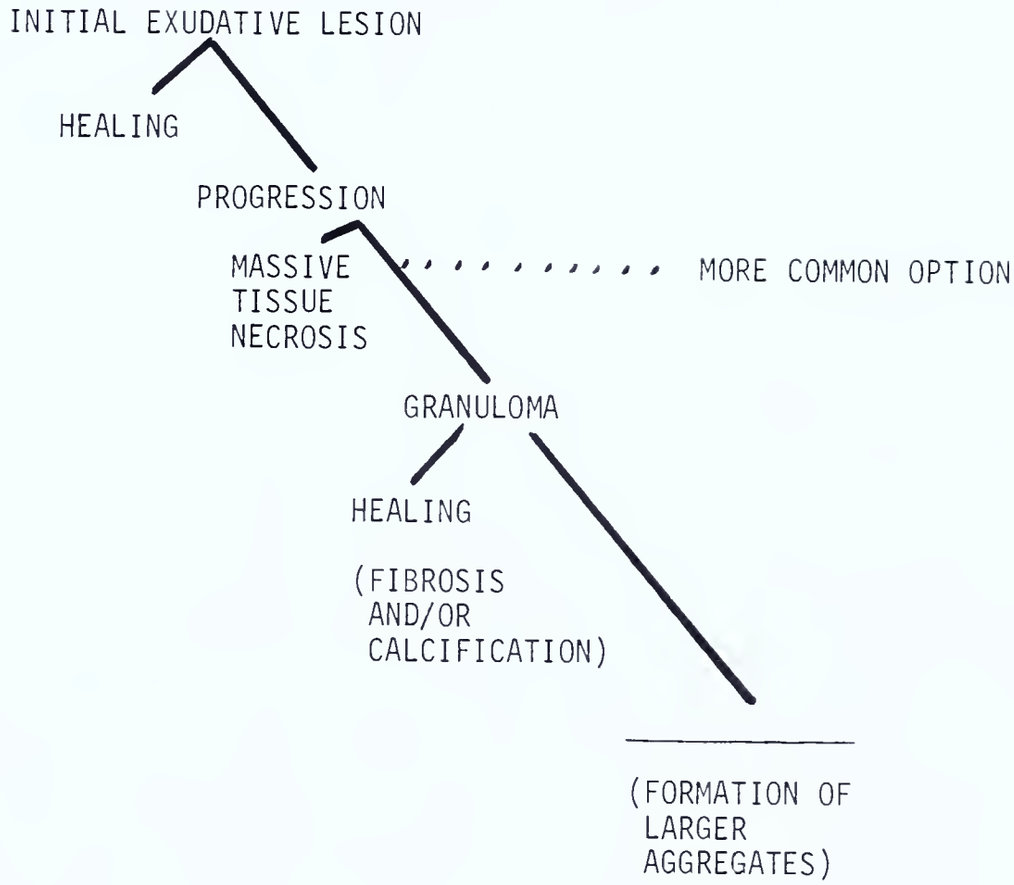
HEAL

WORSEN OR

PROGRESS

13

COMPLETE THE FOLLOWING DIAGRAM:



PROGRESSION

14

THE GRANULOMATOUS LESION MAY

HEAL BY _____AND/OR

_____.

FIBROSIS

CALCIFICATION

15

IF THE GRANULOMA UNDERGOES PROGRESSIVE CHANGE, THIS LEADS TO THE FORMATION OF

_____.

LARGER AGGREGATES

16

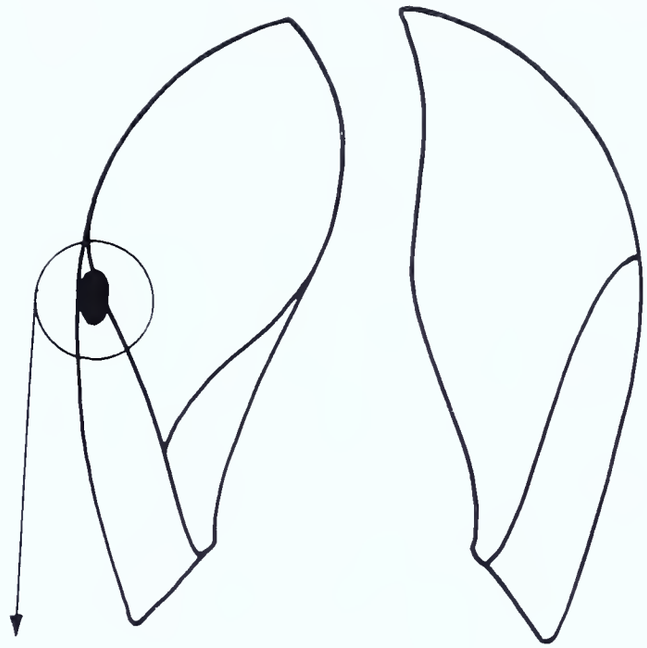
WHERE IN THE LUNG ARE ALL OF THESE LOCAL OPTIONS OCCURRING?

_____

_____

_____

IN PERIPHERAL ALVEOLI IN THE LOWER LOBES OF THE LUNG BENEATH THE PLEURA



INITIAL EXUDATIVE LESION

HEALING

PROGRESSION

MASSIVE TISSUE NECROSIS

MORE COMMON OPTION

GRANULOMA

HEALING (FIBROSIS AND/OR CALCIFICATION)

PROGRESSION (FORMATION OF LARGER AGGREGATES)

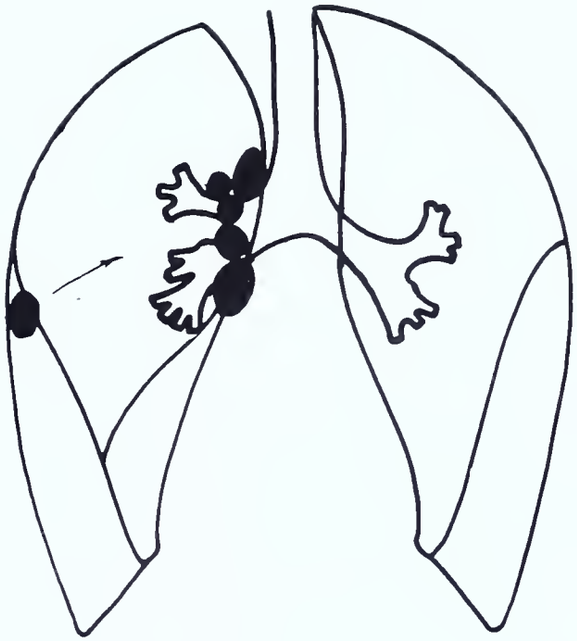
NO RESPONSE

18

THE OPTIONS SUMMARIZED
IN FRAME 17 ARE ONGOING
LOCAL LUNG PARENCHYMAL
PROCESSES.

WHILE THESE EVENTS
OCCUR LOCALLY,
THE TUBERCLE BACILLUS
IS ALREADY TRAVELING
ON A SYSTEMIC ROUTE
WHICH WE WILL NOW EXAMINE.....

NO RESPONSE



19

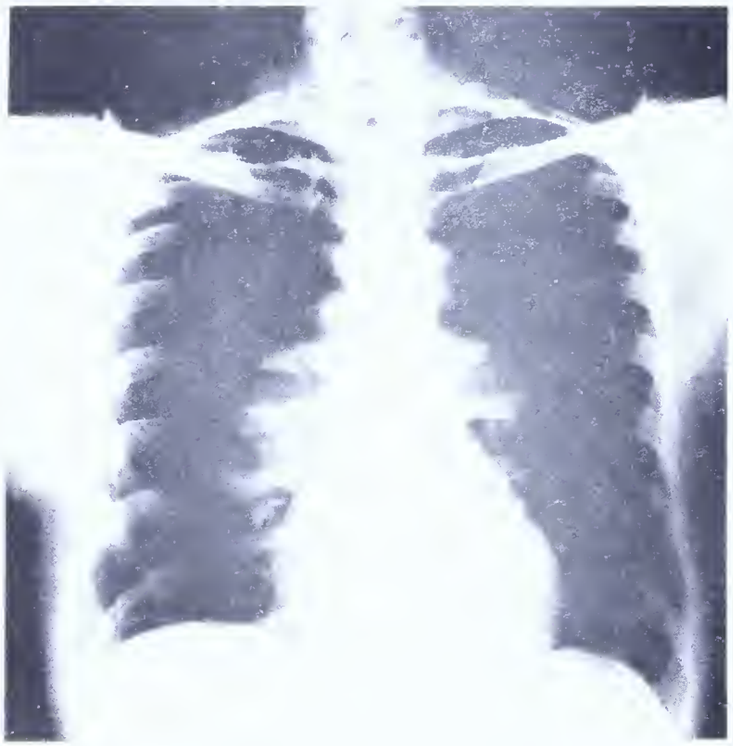
THE TUBERCLE BACILLI IN THEIR
INITIAL PERIPHERAL SITE, MULTIPLY
AT FIRST WITHOUT MUCH INTERFERENCE
FROM THE NON-ALLERGIC HOST.
FROM THIS SUB-PLEURAL FOCUS,
THEY ARE USUALLY DRAINED CENTRALLY
BY THE LYMPHATICS TO THE_____

HILAR NODES

20

WHEN THE BACILLI REACH THE HILUM OF THE LUNG, THEY CONTINUE TO MULTIPLY IN THE _____.

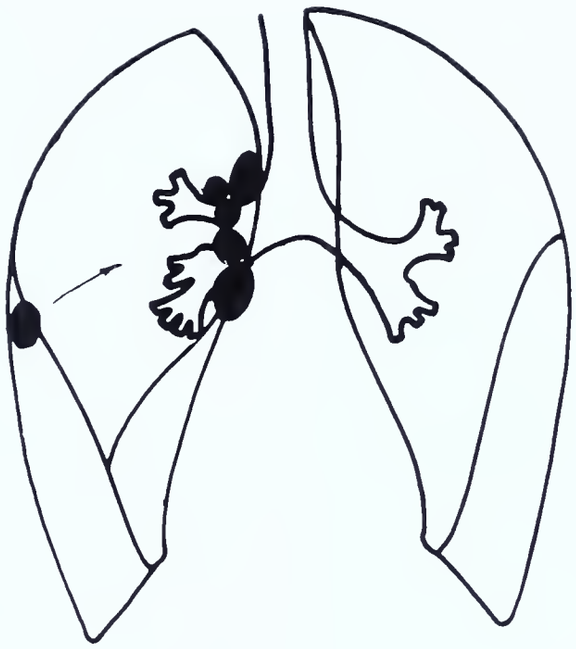
HILAR NODES



21

PRIMARY TUBERCULOSIS, WHETHER IN CHILD OR ADULT, MAY THEREFORE RESULT IN ENLARGEMENT OF THE _____.

HILAR NODES



22

THE COMBINATION OF THE INITIAL PERIPHERAL FOCUS, ENLARGED DRAINING LYMPH NODES AND THE INTERVENING LYMPHANGITIS CONSTITUTES THE PRIMARY COMPLEX.

NO RESPONSE

23

THIS X-RAY IS THE RESULT OF
CALCIFICATION OF THE PERIPHERAL
TUBERCULOUS FOCUS (SHOWN HERE
IN THE RIGHT LOWER LOBE) AND
THE DRAINING HILAR NODES.
YOU ARE THEREFORE LOOKING
AT AN EXAMPLE OF A CALCIFIED
_____.

PRIMARY COMPLEX

24

THE HILAR LYMPH NODES ULTIMATELY DRAIN INTO THE GREAT VEINS AND THEN INTO THE GENERAL CIRCULATION. TUBERCLE BACILLI IN THE HILAR NODES CAN AND DO GAIN ACCESS TO THE

_____.

GENERAL CIRCULATION, BLOODSTREAM (OR EQUIVALENT TERMS)

25

"SILENT" LYMPHOHEMATOGENOUS SPREAD:

(HILAR NODES ------> GENERAL CIRCULATION)

USUALLY OCCURS AT THE TIME OF THE

_____INFECTION.

PRIMARY, INITIAL,(OR EQUIVALENT TERMS)

26

BACTEREMIA IS A COMMON COMPANION

OF _____TUBERCULOSIS.

PRIMARY

27

CIRCLE ONE OF THE UNDERLINED WORDS:

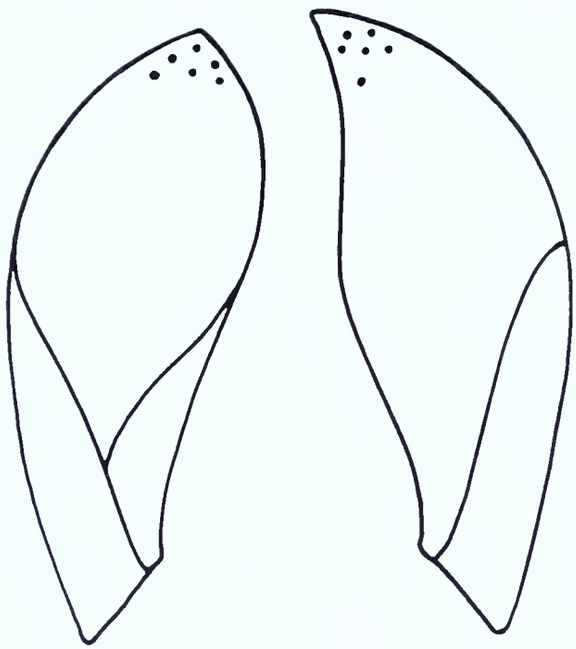
TUBERCULOSIS IS A

(SYSTEMIC) (REGIONAL)

DISEASE.

SYSTEMIC (BECAUSE OF

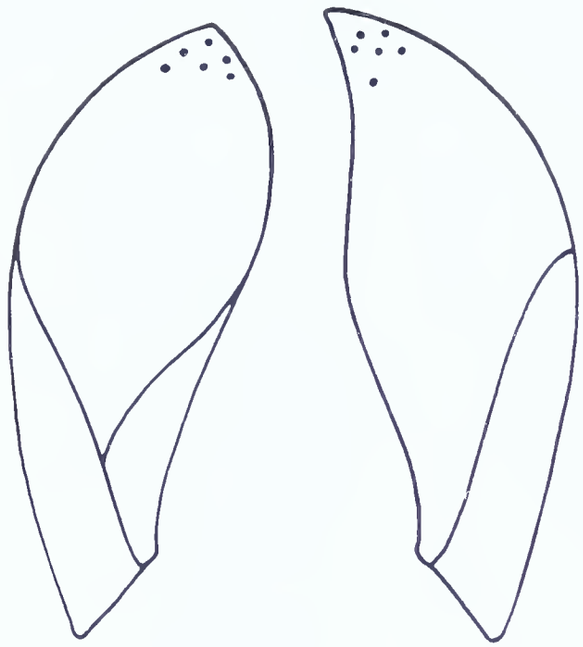
THE ASSOCIATED BACTEREMIA



28

VIA THE BACTEREMIA OF PRIMARY TUBERCULOSIS,
THE TUBERCLE BACILLUS HAS ACCESS TO ALL
PARTS OF THE BODY.
HOWEVER, IT APPEARS THAT CERTAIN SITES
ARE FAVORED ONES AS POINTS OF IMPLANTATION.
ONE SUCH SITE IS IN THE _____.

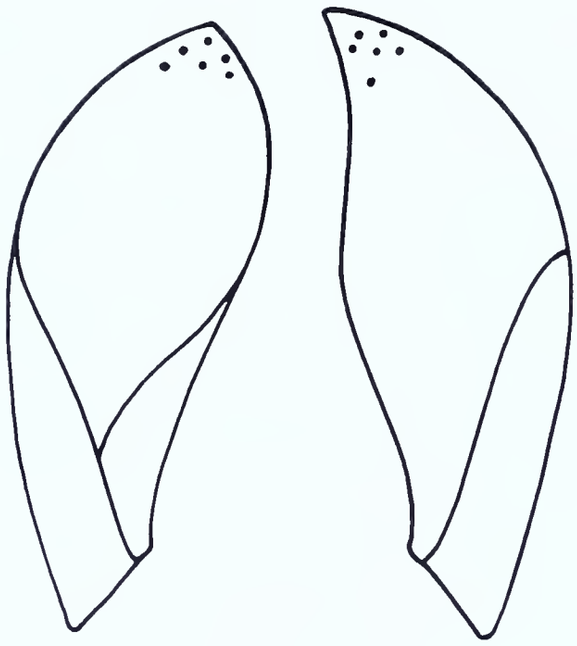
APICES OF THE LUNG



29

ONE IMPORTANT AND FREQUENT SITE
OF METASTATIC IMPLANTATION FOR
THE TUBERCLE BACILLUS
IS IN _____.

THE APICES OF
THE LUNG



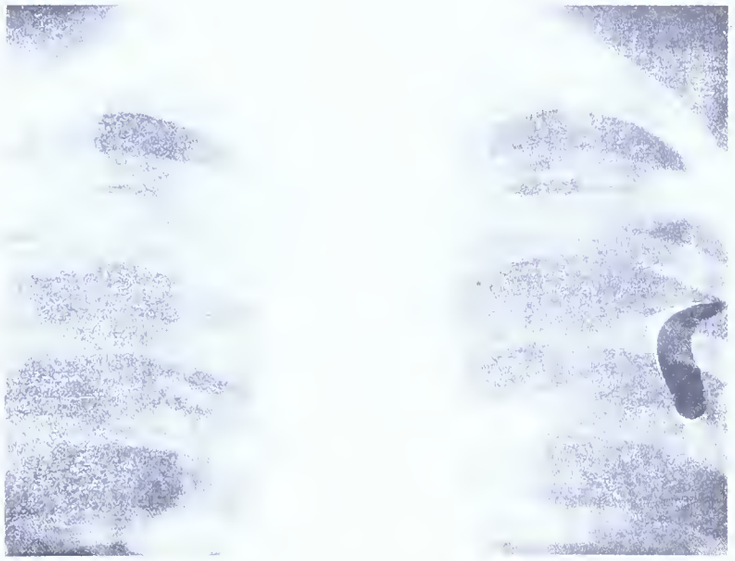
30

GEORG SIMON'S NAME IS OFTEN ASSOCIATED WITH THESE APICAL METASTATIC FOCI OF INFECTION.

THEY ARE OFTEN CALLED, THEREFORE,

_____FOCI.

SIMON



31

THIS X-RAY IS AN EXAMPLE

IN THE LEFT UPPER LOBE

OF A _____FOCUS.

SIMON

32

IN ADDITION TO THE SIMON FOCI ESTABLISHED BY THE BACTEREMIA OF PRIMARY TUBERCULOSIS, THERE ARE SEVERAL OTHER SEEMINGLY PREFERRED SITES:

1. BRAIN
2. KIDNEYS
3. GROWING BONES (METAPHYSIS)

NO RESPONSE

33

EXTRAPULMONARY FOCI OF TUBERCLE BACILLI ARE ESTABLISHED DURING THE TIME OF THE _____ OF THE PRIMARY INFECTION.

BACTEREMIA OR

LYMPHOHEMATOGENOUS SPREAD

34

IT IS BELIEVED THAT MOST EXTRAPULMONARY TUBERCULOSIS ORIGINATES FROM ORGANISMS IMPLANTED DURING THE TIME OF THE _____ OF THE PRIMARY INFECTION.

BACTEREMIA OR LYMPHOHEMATOGENOUS SPREAD

35

THE FAVORED SITES FOR METASTATIC IMPLANTATION OF THE TUBERCLE BACILLUS DURING THE BACTEREMIA OF PRIMARY TUBERCULOSIS ARE:

1. _____
2. BRAIN
3. KIDNEYS
4. GROWING BONES (METAPHYSIS)

APICAL OR SIMON FOCI

36

MOST OF THE PULMONARY AND

EXTRAPULMONARY TUBERCULOSIS

SEEN IN THE ADULT

ORIGINATES FROM ORGANISMS

IMPLANTED DURING THE

TIME OF THE _____

OF THE PRIMARY INFECTION.

BACTEREMIA

OR

LYMPHOHEMATOGENOUS

SPREAD

SO FAR WE HAVE SEEN TWO MAJOR AREAS OF DEVELOPMENT FOR THE TUBERCLE BACILLUS:

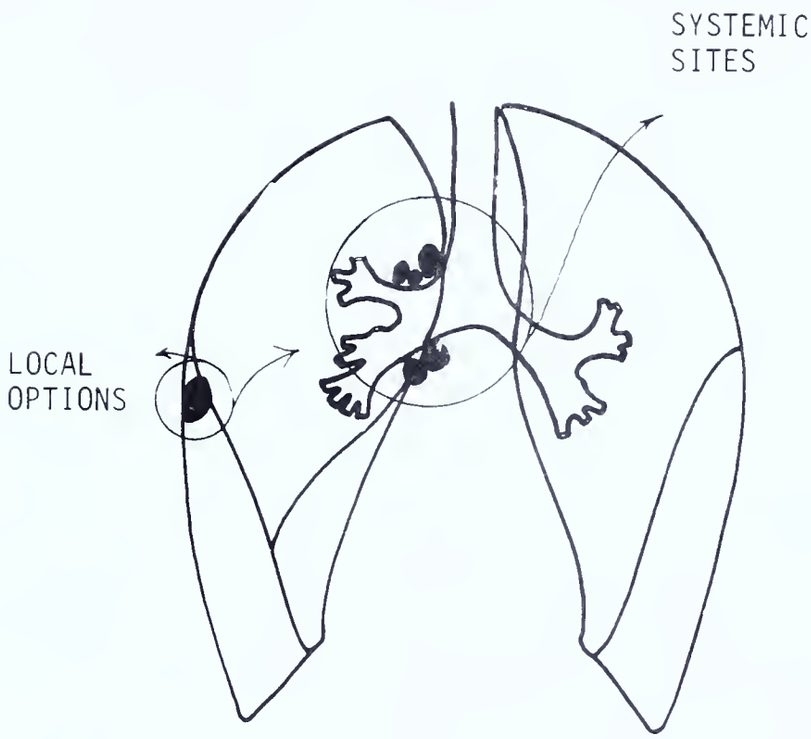
1. THE LOCAL LESIONS PRODUCED IN THE LUNG IN RESPONSE TO THE TUBERCLE BACILLUS, NAMELY, THE EXUDATIVE AND GRANULOMATOUS LESIONS.
2. THE CONCOMITANT BACTEREMIA OF THE INITIAL INFECTION WHICH ESTABLISHES THE TUBERCLE BACILLUS IN CERTAIN FAVORED SITES OF THE BODY, WHICH ARE:

A. _____ THE APICES OF THE LUNG (SIMON FOCI)

B. _____ KIDNEY

C. _____ BRAIN

D. _____ GROWING BONES (METAPHYSIS)



38

WHILE THE TUBERCLE BACILLUS
PLAYS OUT ITS LOCAL AND SYSTEMIC
ROLES, THE DEFENSES OF THE HOST
ARE BEING MARSHALED.
WE WILL NOW TAKE A BRIEF LOOK
AT THE REACTIONS OF THE HOST.

NO RESPONSE

39

APPROXIMATELY 3 TO 8 WEEKS AFTER THE INITIAL INFECTION, A SPECIFIC RESISTANCE AND HYPERSENSITIVITY APPEAR IN THE HOST. THESE PROCESSES ARE DETRIMENTAL TO THE TUBERCLE BACILLI, AS IT HAS BEEN SHOWN EXPERIMENTALLY THAT THE NUMBERS OF ORGANISMS ARE SIGNIFICANTLY _____ AT THIS TIME.

REDUCED

(OR EQUIVALENT TERM)

40

THE DEVELOPMENT OF
THE HYPERSENSITIVE STATE
IN THE HOST DURING THIS
3 TO 8 WEEK PERIOD
IS MIRRORED IN THE
TUBERCULIN TEST.
IT THUS TAKES HOW LONG
FOR CONVERSION OF THE
TUBERCULIN TEST
FROM NEGATIVE TO POSITIVE
AFTER THE INITIAL INFECTION?

3 TO 8 WEEKS

41

THIS INITIAL 3 TO 8 WEEKS AFTER THE PRIMARY INFECTION ALSO MARKS THE ONSET OF CASEATION NECROSIS IN THE PRIMARY FOCUS AND THE DRAINING LYMPH NODES.

NO RESPONSE

42

FOR EACH STATEMENT BELOW, LIST ONE SIGNIFICANT EVENT OCCURRING DURING THE FIRST 3 TO 8 WEEKS AFTER THE PRIMARY INFECTION:

1. SKIN REACTIVITY TO TUBERCULIN:

_____

TUBERCULIN TEST BECOMES POSITIVE

2. PRIMARY SITE OF INFECTION AND DRAINING NODES:

_____

ONSET OF CASEATION NECROSIS OCCURS

43

TO THIS POINT, THE FORCES INVOLVED IN THE PATHOGENESIS OF TUBERCULOSIS CAN BE SUMMED UP BY TWO "VECTORS," EACH MOVING IN AN OPPOSITE DIRECTION. THUS, THE MANIFESTATIONS OF THE PRIMARY INFECTION WILL DEPEND ON THAT "VECTOR" WHICH IS DOMINANT:

P R I M A R Y I N F E C T I O N

TUBERCLE BACILLUS ⟷ HOST'S DEFENSES

A. LOCAL LUNG OPTIONS

B. SYSTEMIC SITES

NO RESPONSE

FIRST,

P R I M A R Y I N F E C T I O N

TUBERCLE BACILLUS HOST'S DEFENSES

MOST OF THE TIME, THE HOST HANDLES THE PRIMARY INFECTION WITHOUT DIFFICULTY. HEALING OCCURS IN BOTH THE METASTATIC SITES OF IMPLANTATION AS WELL AS THE _____ COMPLEX.

PRIMARY

45

THE HEALING WHICH OCCURS, VARIES IN ITS COMPLETENESS IN THE DIFFERENT SITES.

FOR EXAMPLE, YEARS AFTER THE PRIMARY INFECTION, IT IS POSSIBLE TO RECOVER VIABLE TUBERCLE BACILLI FROM THE _____ IN THE APICES OF THE LUNG.

SIMON FOCI

46

IN CONTRAST, YEARS AFTER THE PRIMARY INFECTION, IT IS MUCH LESS POSSIBLE TO RECOVER VIABLE TUBERCLE BACILLI FROM THE _____COMPLEX.

PRIMARY

47

IT IS CLEAR THAT THE TUBERCLE BACILLUS HAS THE ABILITY TO SURVIVE FOR LONG PERIODS OF TIME IN THE SIMON FOCI AND OTHER EXTRAPULMONARY SITES.

NO RESPONSE

48

YEARS AFTER THE PRIMARY INFECTION (PRIMARY TUBERCULOSIS), THEREFORE, THE HOST MAY DEVELOP OVERT POST-PRIMARY TUBERCULOSIS AND/OR EXTRA_____TUBERCULOSIS.

PULMONARY

49

PRIMARY TUBERCULOSIS IS
A DISEASE OF THE LOWER LOBES
OF THE LUNG (USUALLY).

IN CONTRAST,
POST-PRIMARY TUBERCULOSIS
IS PREDOMINANTLY A DISEASE
OF THE _____.

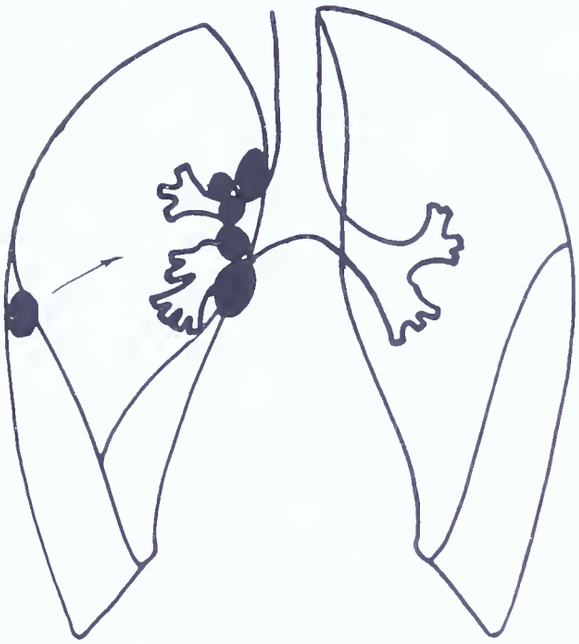
UPPER LOBES

50

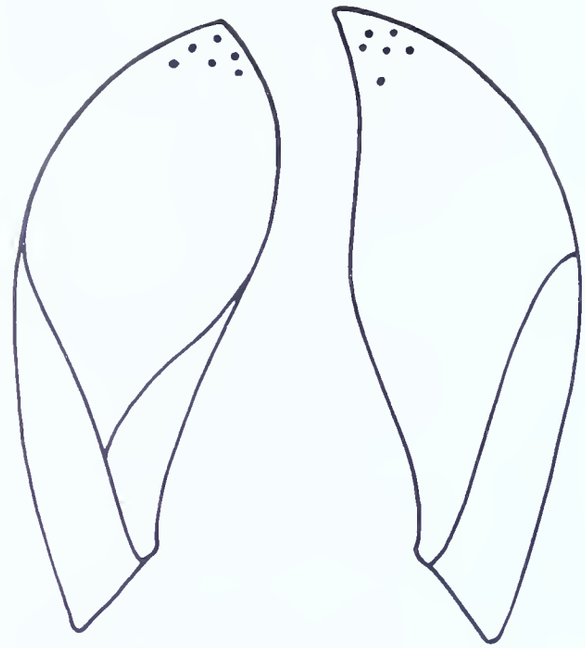
SIMON FOCI ARE LOCATED
IN THE _____
LOBES OF THE LUNG.

UPPER

AN OVERVIEW[1]:



B A C T E R E M I A



LIMITED PROGRESSION TO
APICAL OR SIMON FOCI

OTHER EXTRAPULMONARY

SITES ESTABLISHED:

BRAIN
KIDNEYS
BONES

NEWLY INFECTED:

PRIMARY TUBERCULOSIS

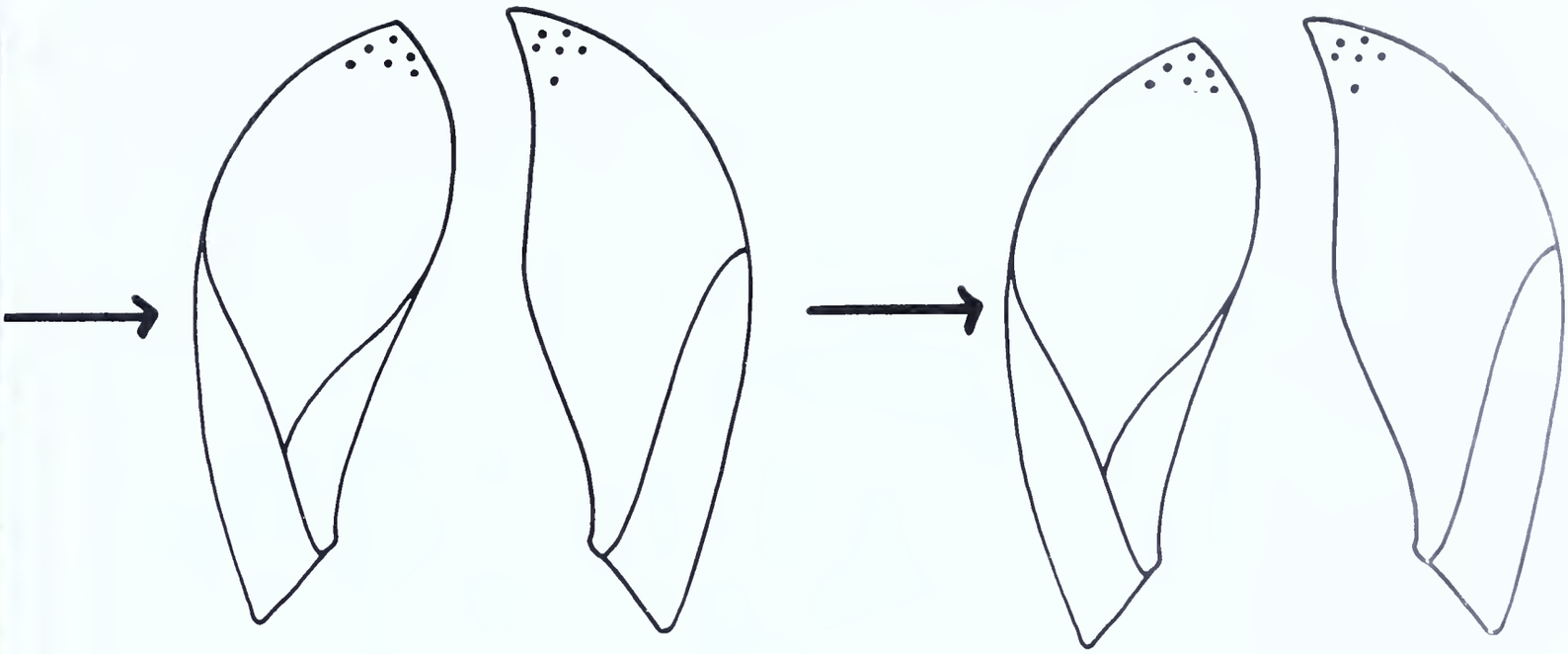
TIME AFTER INFECTION

WHEN OVERT DISEASE

MAY OCCUR:

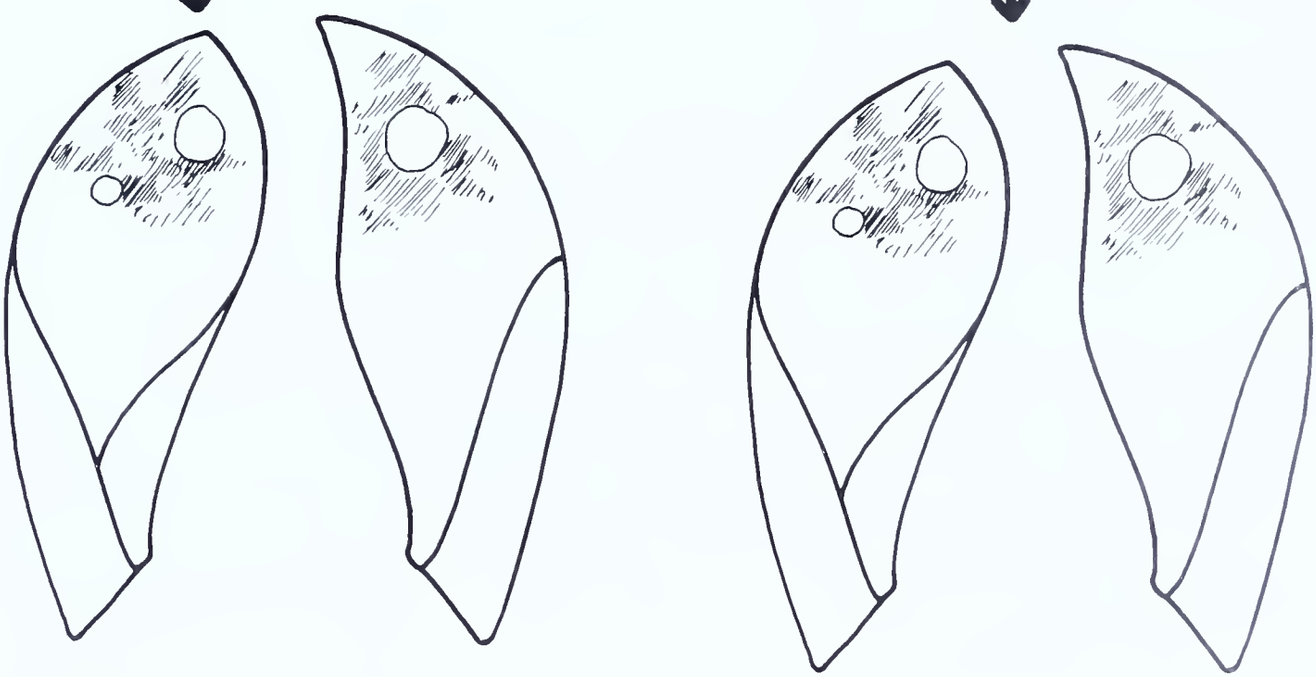
FIRST YEAR

[1]MODIFIED FROM CHAPTER ON TUBERCULOSIS BY WILLIAM W. STEAD IN HARRISON: PRINCIPLES OF INTERNAL MEDICINE. COPYRIGHT, 1966 BY McGRAW-HILL, INC. USED WITH PERMISSION OF McGRAW-HILL BOOK COMPANY.



APICAL FOCI

APICAL FOCI



REACTIVATION IN EARLY ADULTHOOD

REACTIVATION IN MIDDLE OR LATE ADULTHOOD

POST-PRIMARY PULMONARY

& EXTRAPULMONARY TUBERCULOSIS

5 YEARS

25-50 YEARS

NO

RESPONSI

54

PRIMARY TUBERCULOSIS IS USUALLY A SELF-LIMITING PROCESS ALTHOUGH THE _____FOR FUTURE DISEASE IS ESTABLISHED.

BASIS, POTENTIAL OR EQUIVALENT TERM

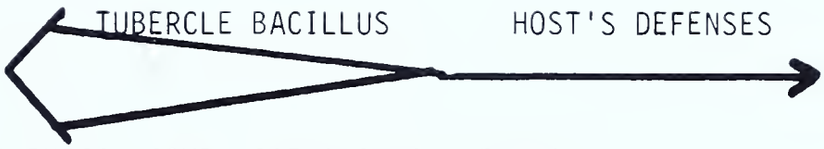
55

TUBERCLE BACILLUS HOST'S DEFENSES

ON THE OTHER HAND, THE HOST MAY NOT HANDLE THE _____INFECTION WELL.

PRIMARY OR INITIAL

56



CLINICAL COMPLICATIONS MAY DEVELOP

FROM EITHER THE:

A. LOCAL LUNG LESIONS OR

B. SYSTEMIC SITES, WHICH ARE

THE RESULT OF THE _____

OF THE PRIMARY INFECTION.

BACTEREMIA

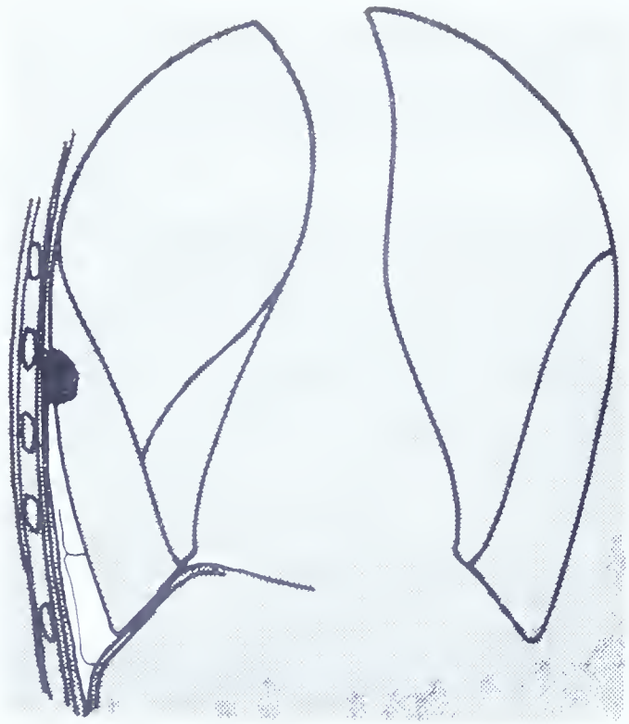
57

LET'S NOW LOOK AT THE COMPLICATIONS

WHICH MAY ARISE FROM THE LOCAL

PARENCHYMAL LESIONS.

NO RESPONSE

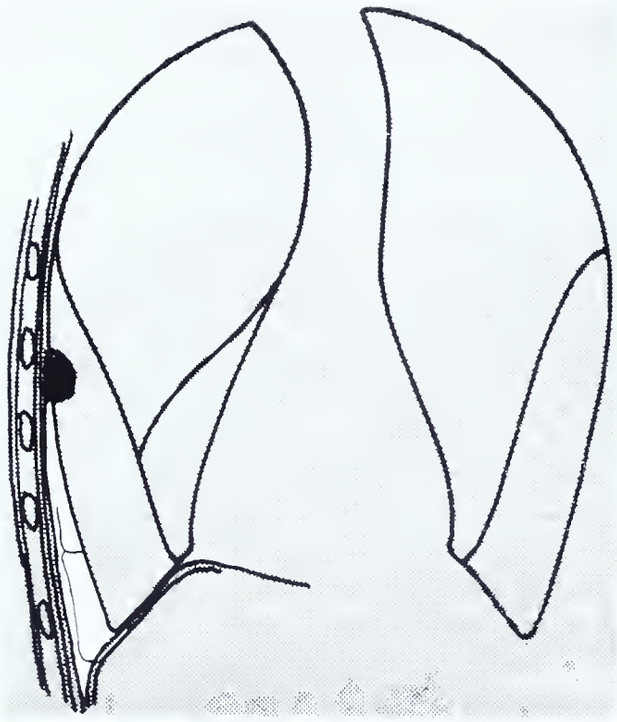


58

THE INITIAL SUB-PLEURAL FOCUS
USUALLY PRODUCES A SMALL AREA
OF OVERLYING PLEURITIS WITHOUT
A CLINICALLY DETECTABLE EFFUSION.

HOWEVER, AS HYPERSENSITIVITY
BECOMES ESTABLISHED IN THE HOST
THE SHEDDING OF A SMALL NUMBER
OF TUBERCLE BACILLI INTO THE
PLEURAL SPACE IS ENOUGH TO
ELICIT A _____.

PLEURAL EFFUSION



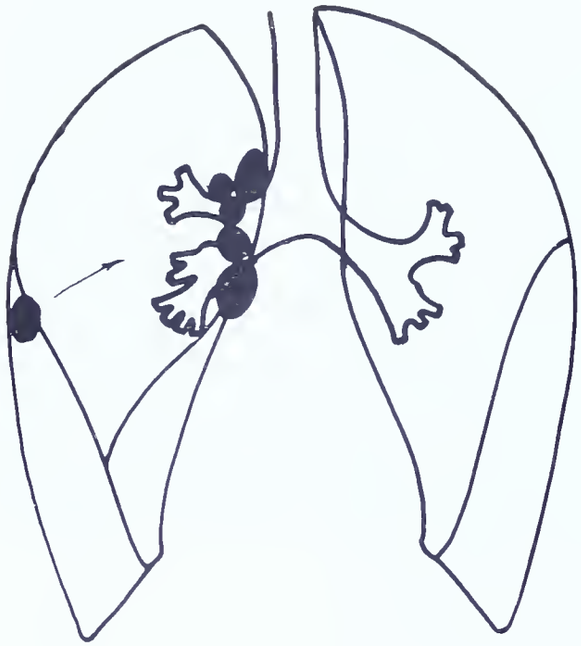
59

THUS, PRIMARY TUBERCULOSIS MAY

BE ASSOCIATED WITH THE PRODUCTION

OF A _____.

PLEURAL EFFUSION

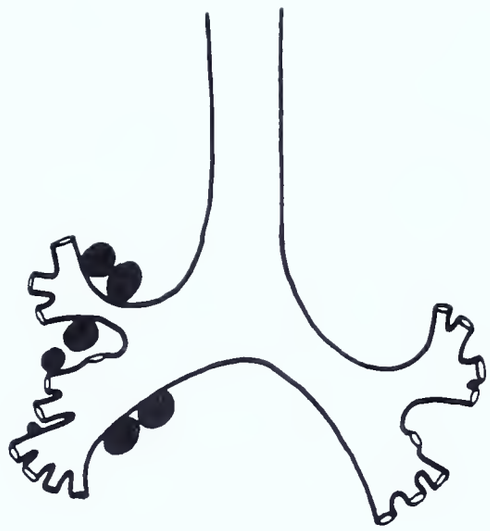


60

ANOTHER COMPLICATION OF PRIMARY TUBERCULOSIS MAY DEVELOP IN RELATIONSHIP TO THE DRAINING

_____.

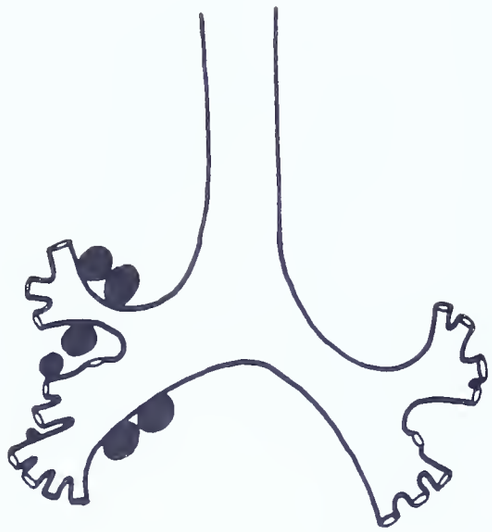
LYMPH NODES



61

DRAINING LYMPH NODES GIVE RISE TO CERTAIN OF THE COMPLICATIONS OF PRIMARY TUBERCULOSIS, BECAUSE OF PROXIMITY TO _____.

BRONCHI



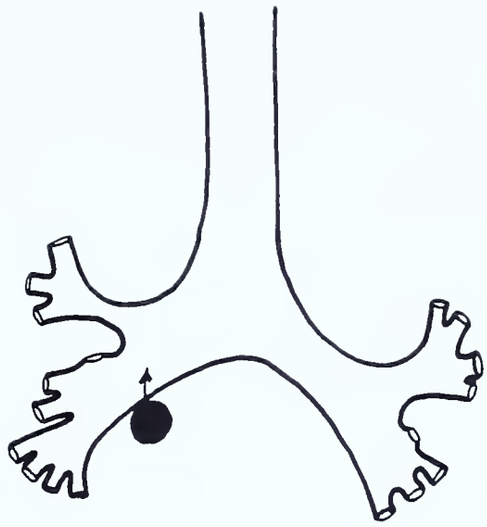
62

ENLARGED DRAINING LYMPH NODES

MAY COMPRESS NEIGHBORING

_____.

BRONCHI



63

BRONCHIAL COMPRESSION MAY THEN BE ASSOCIATED WITH ANOTHER OPTION THAT THE ENLARGED DRAINING LYMPH NODES MAY FOLLOW. THIS IS:

_____.

EROSION OR PERFORATION INTO THE BRONCHUS (OR EQUIVALENT)

64

THE MECHANISMS BY WHICH ENLARGED DRAINING LYMPH NODES CAN PRODUCE CERTAIN OF THE CLINICAL COMPLICATIONS OF PRIMARY TUBERCULOSIS ARE:

1. _____ COMPRESSION

2. COMPRESSION AS WELL AS

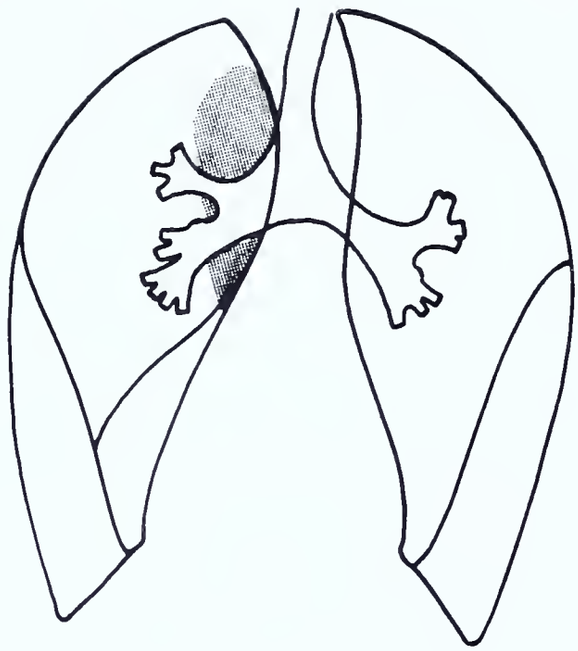
_____ EROSION

SEGMENTAL

LESION IN

RIGHT UPPER

LOBE



65

THUS, BRONCHIAL COMPRESSION, THEN EROSION BY THE DRAINING INFECTED LYMPH NODES, CAN PRODUCE TWO GENERAL TYPES OF LESIONS. THE FIRST SHOWN IS _____IN NATURE.

SEGMENTAL

66

THIS X-RAY IS OF A CHILD WITH PRIMARY TUBERCULOSIS. THE COMPLICATION ILLUSTRATED HERE IS COLLAPSE AND CONSOLIDATION OF A PORTION OF THE RIGHT UPPER LOBE PRODUCED BY BRONCHIAL COMPRESSION AND EROSION.

THIS COLLAPSE-CONSOLIDATION LESION IS AN EXAMPLE OF A _____TYPE OF LESION.

SEGMENTAL

67

COMPLETE THIS TABLE:

THE MECHANISMS BY WHICH ENLARGED DRAINING LYMPH NODES CAN PRODUCE CERTAIN OF THE CLINICAL COMPLICATIONS OF PRIMARY TUBERCULOSIS ARE:

1. _____, COMPRESSION

2. COMPRESSION AS WELL AS _____ OF A BRONCHUS: EROSION

a) COMPRESSION PLUS _____ EROSION CAN PRODUCE A _____ SEGMENTAL TYPE OF LESION.

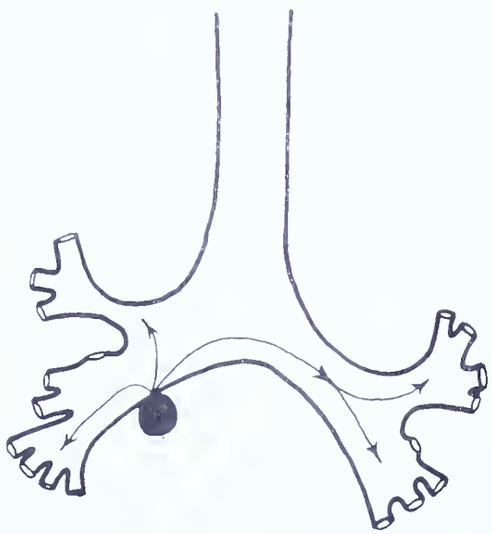
68

SEGMENTAL LESIONS PRODUCED BY COMPRESSION AND EROSION BY LYMPH NODES (THEREBY EMPTYING CASEOUS MATERIAL INTO THE BRONCHUS) ARE BEST KNOWN AS _____-_____LESIONS. COLLAPSE-CONSOLIDATION

69

WHEN INTRABRONCHIAL SPREAD OF CASEOUS MATERIAL FROM PERFORATING LYMPH NODES IS FAIRLY WELL LOCALIZED, A _____ TYPE OF LESION RESULTS.

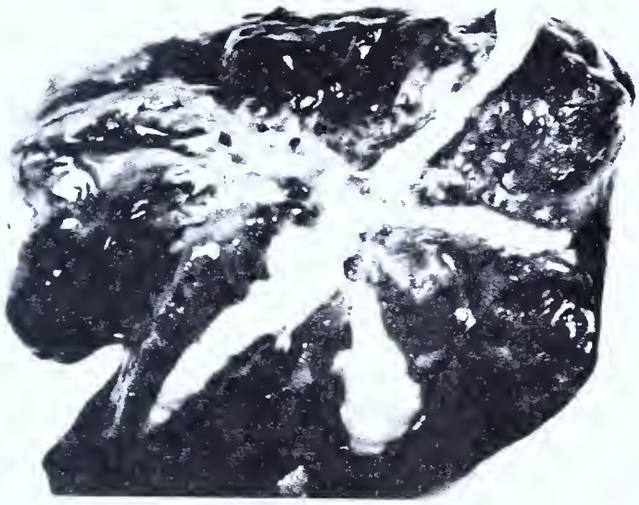
SEGMENTAL OR COLLAPSE-CONSOLIDATIO



70

IN ADDITION TO SEGMENTAL LESIONS, BRONCHIAL EROSION MAY LEAD TO THE SPREAD OF CASEOUS MATERIAL TO OTHER _____.

BRONCHI



71

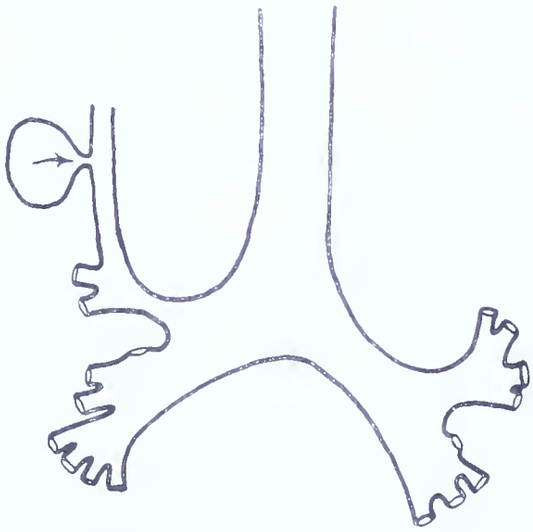
AN EXAMPLE OF DIFFUSE INTRABRONCHIAL SPREAD OF CASEOUS MATERIAL IN THE LUNG.

NO RESPONSE

72

A THIRD OPTION OPEN TO PRIMARY TUBERCULOSIS IS UNCHECKED LOCAL GROWTH OF THE INITIAL SUB-PLEURAL LESION. THIS GROWTH RESULTS IN A LARGER MASS OF TUBERCULOUS MATERIAL IN THE LUNG PARENCHYMA.

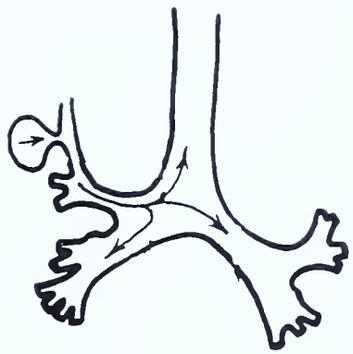
NO RESPONSE



73

THIS LARGER MASS OF TUBERCULOUS MATERIAL MAY EMPTY INTO AN ADJACENT BRONCHUS LEAVING BEHIND IN THE LUNG AN EXCAVATED AREA CALLED A _____.

CAVITY



74

CAVITIES ARE GENERATED BY THE EMPTYING OF CASEOUS MATERIAL INTO BRONCHI.

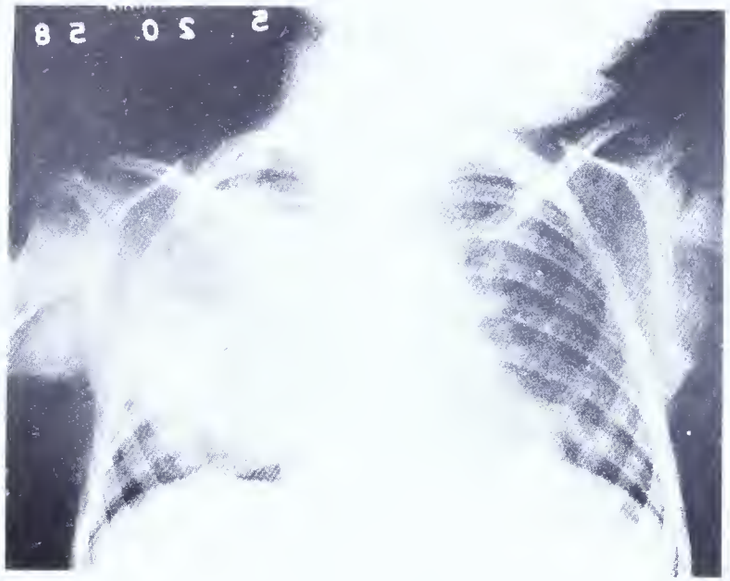
IF THIS OCCURS IN PRIMARY TUBERCULOSIS, IT MAY LEAD TO EXTENSIVE _____SPREAD.

INTRABRONCHIAL

75

PRIMARY TUBERCULOSIS, WHICH IS ASSOCIATED WITH CAVITATION AND EXTENSIVE BRONCHOGENIC SPREAD IS KNOWN AS PROGRESSIVE PRIMARY TUBERCULOSIS.

NO RESPONSE



76

PROGRESSIVE PRIMARY TUBERCULOSIS

NO RESPONSE

77

UNCHECKED LOCAL GROWTH

OF THE INITIAL LESION

IN PRIMARY TUBERCULOSIS

WITH CAVITY FORMATION AND

WIDESPREAD BRONCHIAL DISSEMINATION

IS KNOWN AS _____.

PROGRESSIVE

PRIMARY

TUBERCULOSIS

78

PRIMARY TUBERCULOSIS MAY GIVE RISE TO

THE FOLLOWING COMPLICATIONS:

1. _____

PLEURAL EFFUSION

2. THE MECHANISMS BY WHICH INFECTED LYMPH NODES CAN PRODUCE THE CLINICAL COMPLICATIONS IN PRIMARY TUBERCULOSIS ARE:

1. _____ COMPRESSION

2. _____ COMPRESSION

AND EROSION, LEADING EITHER TO

a) A _____ TYPE OF LESION, SEGMENTAL (COLLAPSE-CONSOLIDATION)

OR TO

b) EXTENSIVE _____ INTRABRONCHIAL

SPREAD.

3. _____ PROGRESSIVE PRIMARY TUBERCULOSIS

THE COMPLICATIONS WHICH OCCUR

AT SYSTEMIC SITES ARE THE

NEXT TOPIC.

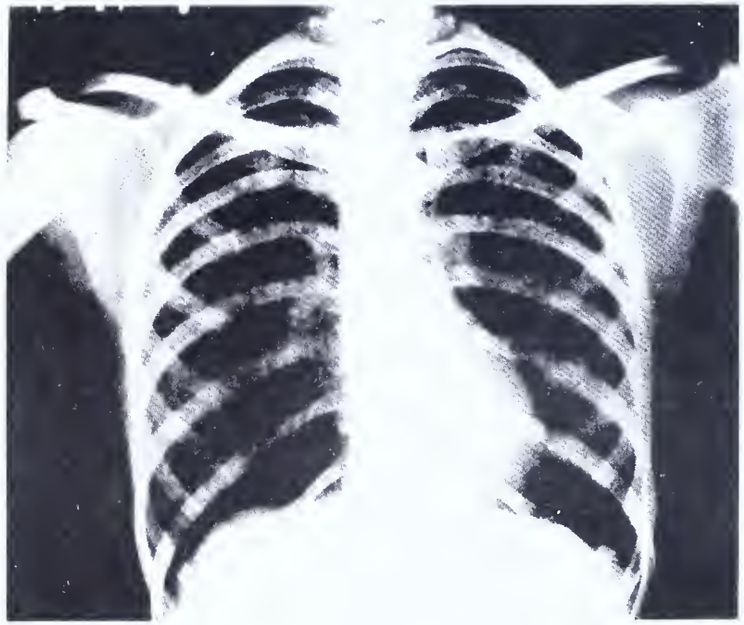
THE FIRST OF THESE IS RELATED

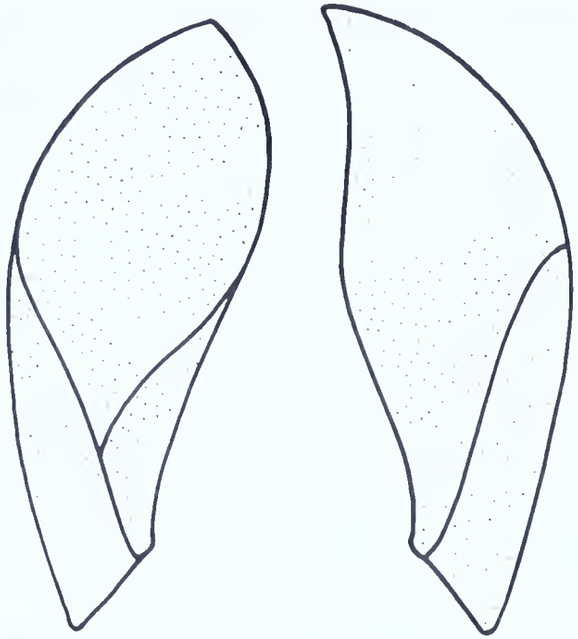
TO THE MAGNITUDE OF THE

BACTEREMIA WHICH ACCOMPANIES

THE INITIAL INFECTION.

NO RESPONSE





80

CONTINUED GROWTH OF THE PRIMARY FOCUS OF INFECTION MAY RESULT IN A LARGE INNOCULUM OF TUBERCLE BACILLI GAINING ACCESS TO THE GENERAL CIRCULATION.

THIS ACCESS IS EITHER VIA DIRECT EMPTYING INTO A BLOOD VESSEL OR BY MASSIVE LYMPHOHEMATOGENOUS SPREAD.

THIS COMPLICATION LEADS TO THE DEPOSITION OF MILLET SIZE LESIONS IN VARIOUS ORGANS OF THE BODY AND IS KNOWN AS _____.

MILIARY TUBERCULOSIS

81

MASSIVE LYMPHOHEMATOGENOUS SPREAD FROM THE INITIAL FOCUS OF INFECTION IN THE LUNG MAY RESULT IN

_____.

MILIARY TUBERCULOSIS

82

THE PRESENCE OF TUBERCLE BACILLI IN THE CEREBROSPINAL FLUID IS ANOTHER MAIN OPTION OF PRIMARY TUBERCULOSIS. THIS FINDING IS ASSOCIATED WITH TUBERCULOUS

_____.

MENINGITIS

83

TUBERCULOUS MENINGITIS MAY OR MAY NOT BE ASSOCIATED WITH MILIARY TUBERCULOSIS.

NO RESPONSE

84

AS OPPOSED TO DIRECT MENINGEAL SEEDING VIA THE BLOOD, IT IS FELT THAT THE USUAL MECHANISM FOR THE ESTABLISHMENT OF TUBERCULOUS MENINGITIS IS THE EXTENSION OF A CEREBRAL SUB-CORTICAL FOCUS INTO THE _____.

SUBARACHNOID SPACE
OR CEREBROSPINAL FLUID

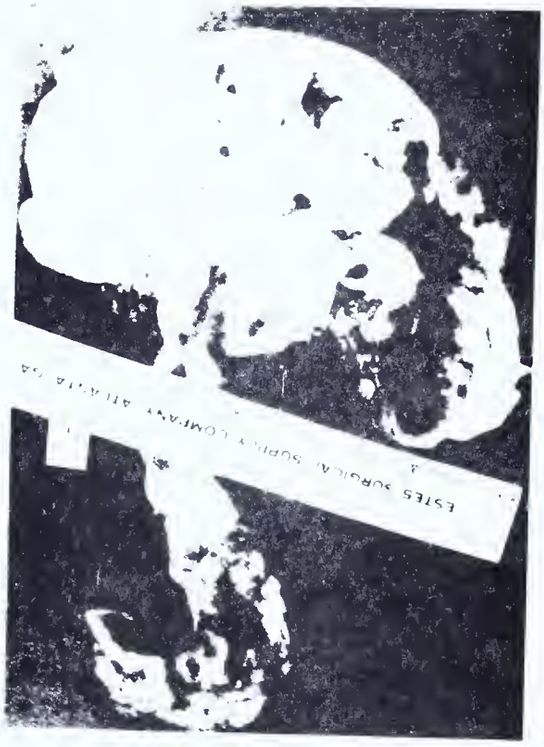
85

TUBERCULOSIS OF THE VERTEBRAE IS THE MOST COMMON SKELETAL COMPLICATION OF PRIMARY TUBERCULOSIS.

ILLUSTRATED HERE IS ANOTHER EXAMPLE OF TUBERCULOSIS OCCURRING AT A "METASTATIC SITE", WHICH IN THIS CASE IS THE

_____.

HIP (LEFT)



86

LASTLY, A METASTATIC FOCUS MAY

PROGRESS IN THE SITE SHOWN ABOVE,

LEADING TO _____TUBERCULOSIS.

RENAL

87

ALTHOUGH NEARLY ANY ORGAN MAY BE AFFECTED BY THE TUBERCLE BACILLUS, WE HAVE LISTED THE COMMON SYSTEMIC COMPLICATIONS WHICH FOLLOW UPON PRIMARY TUBERCULOSIS.

THESE ARE:

1. _____

2. _____

3. _____

4. _____

MENINGITIS

MILIARY

BONE (MOST COMMONLY, VERTEBRAE)

RENAL

IN ADDITION,

THE LOCAL COMPLICATIONS OF PRIMARY TUBERCULOSIS DISCUSSED PREVIOUSLY ARE:

1. _____ PLEURAL EFFUSION

2. BRONCHIAL COMPRESSION AND _____ EROSION

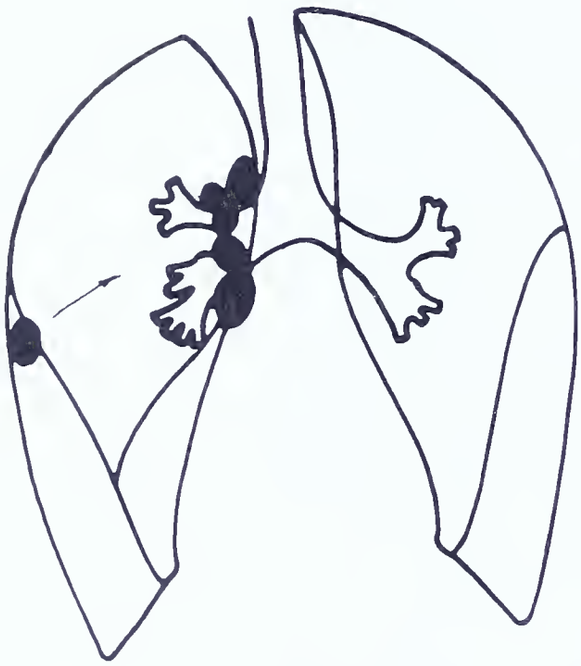
   LEADING TO

   a) A _____ TYPE OF LESION, OR SEGMENTAL

   b) DIFFUSE _____ SPREAD. INTRABRONCHIAL

3. _____ PROGRESSIVE PRIMARY TUBERCULOSIS

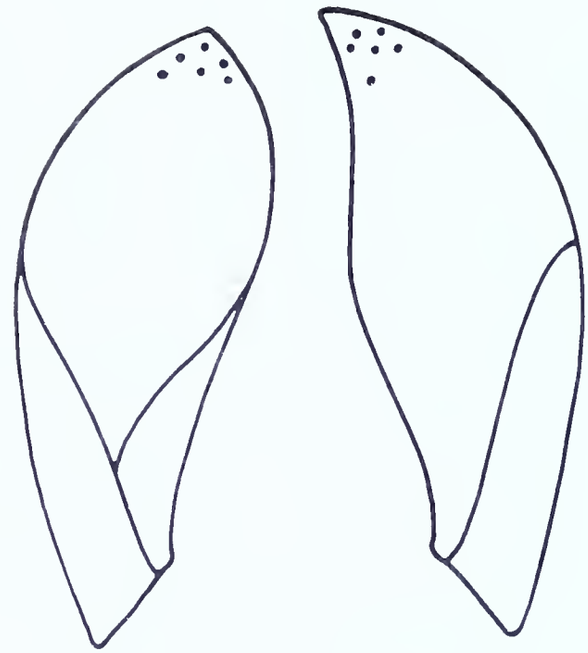
AN OVERVIEW[1]:



NEWLY INFECTED:

PRIMARY TUBERCULOSIS

B A C T E R E M I A



LIMITED PROGRESSION TO
APICAL OR SIMON FOCI

LOCAL COMPLICATIONS:
A. EFFUSION (PLEURAL)
B. BRONCHIAL COMPRESSION/ EROSION WITH SEGMENTAL AND EXTENSIVE LESIONS
C. PROGRESSIVE PRIMARY

SYSTEMIC COMPLICATIONS:
A. MILIARY
B. MENINGEAL
C. BONE
D. RENAL

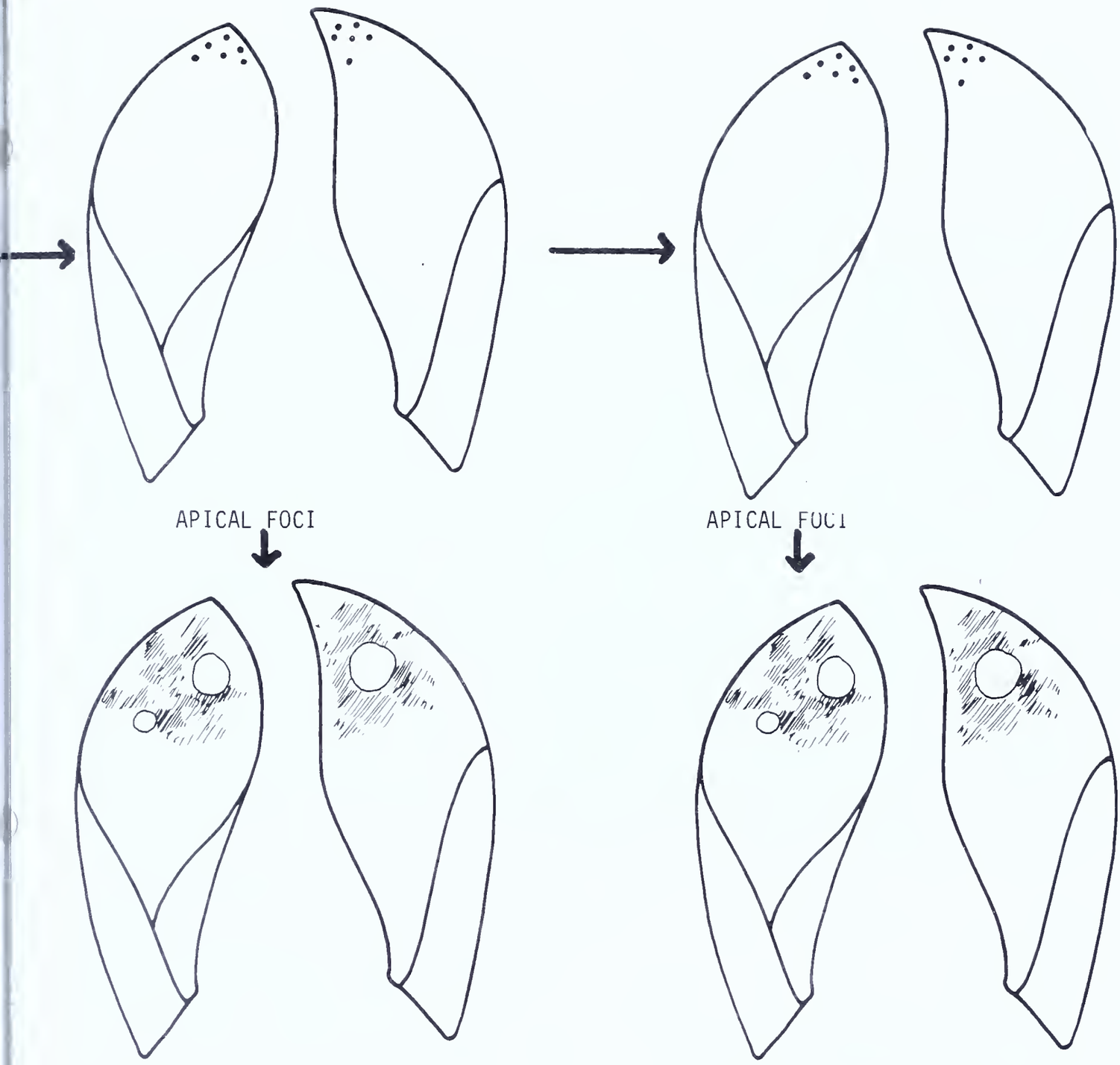
TIME AFTER INFECTION

WHEN OVERT DISEASE

MAY OCCUR:

FIRST YEAR

[1]MODIFIED FROM CHAPTER ON TUBERCULOSIS BY WILLIAM W. STEAD IN HARRISON: PRINCIPLES OF INTERNAL MEDICINE. COPYRIGHT, 1966 BY McGRAW-HILL, INC. USED WITH PERMISSION OF McGRAW-HILL BOOK COMPANY.



POST-PRIMARY PULMONARY

& EXTRAPULMONARY TUBERCULOSIS

5 YEARS

25-50 YEARS

NO

RESPONSE

89

THE PATHOGENESIS OF PRIMARY
TUBERCULOSIS IN THE CHILD
OR IN THE ADULT IS BASICALLY
THE SAME.
THE DIFFERENCE LIES IN THE
TYPE AND FREQUENCY OF COMPLICATIONS
WHICH ARISE.

NO RESPONSE

FOR EXAMPLE, MASSIVE REGIONAL ADENOPATHY
SO CHARACTERISTIC OF PRIMARY TUBERCULOSIS IN
CHILDREN LEADS MORE FREQUENTLY TO BRONCHIAL
COMPRESSION AND EROSION COMPLICATIONS THAN IS
SEEN WITH PRIMARY TUBERCULOSIS IN ADULTS.

90

AT ANY AGE,
PERSONS WHO HAVE BEEN RECENTLY
INFECTED ARE AT THE HIGHEST
_____ OF DEVELOPING
THE COMPLICATIONS OF PRIMARY
TUBERCULOSIS.

RISK, CHANCE
(OR EQUIVALENT TERM)

91

IT HAS BEEN SHOWN THAT THE COMPLICATIONS OF THE INITIAL INFECTION - IF THEY DO OCCUR - ARE USUALLY SEEN WITHIN TWELVE MONTHS OF THE DIAGNOSIS OF _____TUBERCULOSIS.

PRIMARY

92

HOWEVER, AFTER BEING DORMANT FOR LONG PERIODS, TUBERCULOUS FOCI CAN GIVE RISE TO SIMILAR COMPLI-CATIONS DURING THE TIME OF _____PRIMARY TUBERCULOSIS.

POST-

93

FOR EXAMPLE, _____ TUBERCULOSIS MAY HAVE A DORMANT PERIOD OF 1-25 YEARS BEFORE IT BECOMES MANIFEST CLINICALLY.

RENAL

94

THERE IS NO WELL DEFINED
PERIOD OF TIME WHICH SEPARATES PRIMARY
TUBERCULOSIS AND ITS COMPLICATIONS
FROM POST-PRIMARY TUBERCULOSIS AND
ITS SIMILAR COMPLICATIONS.

THESE ARE ARBITRARY DISTINCTIONS
IN WHICH WE ATTEMPT TO FIT THE
NATURAL HISTORY OF TUBERCULOSIS
INTO CONCEPTS CONVENIENT FOR
OURSELVES.

NO RESPONSE

95

THE MANIFESTATIONS OF
POST-PRIMARY TUBERCULOSIS
ARE USUALLY SEEN IN THE LUNG.
HOWEVER, EXTRAPULMONARY SITES
MAY BE THE WAY IN WHICH
POST-PRIMARY TUBERCULOSIS
BECOMES APPARENT.
THESE EXTRAPULMONARY FOCI WERE
OFTEN ESTABLISHED AT SOME POINT
IN THE PAST, SPECIFICALLY
DURING THE TIME OF THE
BACTEREMIA OF THE _____ PRIMARY OR INITIAL
INFECTION.

96

PRIMARY TUBERCULOSIS PUTS THE
HOST IN A POSITION OF DOUBLE
JEOPARDY.
THE PRIMARY MAY HEAL ONLY TO
GIVE RISE TO DISEASE DURING
LATER LIFE.
THIS WOULD BE CALLED
_____ _____ TUBERCULOSIS. POST-PRIMARY

97

WHILE ANSWERING THE MEDICAL CONSULT ON A CASE OF RENAL TUBERCULOSIS, THE STUDENT NURSE ASKS YOU ABOUT THE PATHOGENESIS OF GENITOURINARY TUBERCULOSIS. YOUR RESPONSE WOULD BE:

_____

_____

_____

_____

THE BACTEREMIA OF PRIMARY TUBERCULOSIS LEADS TO METASTATIC FOCI AND ONE OF THESE IS IN THE KIDNEYS.

USUALLY, AFTER A LONG DORMANT PERIOD, THESE FOCI REACTIVATE AND GIVE RISE TO ONE FORM OR ANOTHER OF POST-PRIMARY TUBERCULOSIS.

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